The 2D/3D method of characteristics for nuclear reactor whole core neutron transport computation

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The research and development of high-fidelity numerical reactor technology has been a focal point in the international nuclear engineering field over the past 20 years. This approach, rooted in "first principle" ideology, integrates the latest supercomputing platforms and advanced numerical algorithms, moving away from traditional research methods that rely heavily on approximations and empirical formulas. It aims for strict and accurate mathematical modeling of nuclear reactor problems. The three-dimensional whole core neutron transport calculation stands as the core aspect of high-fidelity numerical reactor technology, predominantly implemented through the 2D/1D method of characteristics (MOC). The 2D/1D method experiences instability when dealing with problems with strong axially heterogeneities due to its reliance on the traversal integration technique and the low-order diffusion approximations. A newer method, the 2D/3D approach, has emerged in recent years as a novel whole core MOC transport computation method. It discretizes axially using discontinuous finite element method (DFEM) and explicitly couples the 2D MOC equations of each layer, thus effectively circumventing the traversal integration process inherent in the 2D/1D method. This report details the theoretical model of the 2D/3D MOC approach and highlights our contributions to this field, which include the development of iterative and acceleration algorithms, extensions in higher-order trial function spaces, and advancements in multi-physics coupling algorithms.